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Using Line Intersect Sampling to Predict Spruce Beetle Populations in Logging Residue

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Strategic Importance

The spruce beetle, *Dendroctonus rufipennis* (Kirby), breeds in all native spruces and occurs throughout the range of white and Engelmann spruce, the main hosts, in Canada. When spruce beetle populations become large enough, they cause extensive damage by attacking and killing spruce trees. Outbreaks usually last from 2 to 5 years, and can seriously deplete the number of large-diameter spruce trees in a forest.

Endemic populations of spruce beetles normally breed under the bark of windfalls, and injured or stressed trees. In the presence of man-made disturbances, they also breed readily in fresh harvesting residues such as stumps, butts, tops, and log fragments that have retained their bark. Large populations built up in slash may be precursors of outbreaks in trees. Either large-scale windthrow or large accumulations of slash have preceded all recorded outbreaks of spruce beetle. However, such conditions do not always lead to outbreaks because other factors like stand susceptibility and climate come into play.

Following logging, the forest manager should determine the need for, and the appropriate number of, trap trees. An estimate that is too high will result in unnecessary destruction of trees and additional work for samplers. If the estimate is too low, there may be a spill-over of beetles into adjacent live trees. A trap tree is a man-made windfall. It is a large-diameter, living tree felled into the surrounding forest, left unbucked and not limbed. A trap tree may or may not be pheromone baited, and must be extracted and treated before the next beetle flight. Beetles attacking a trap tree will not be available to attack other living trees. As a rule of thumb, five to ten standing trees will be protected by each trap tree.

Responsible decisions regarding the application of remedial measures, such as trap tree felling, can be made only if the forest manager has reliable knowledge of the size of the spruce beetle population. The line intersect method described here gives the manager a tool with which to quantify the bark surface area in clearcut areas, predict the likely productivity of spruce beetles associated with that bark area, and determine how many trap trees will be required to protect trees in the surrounding stands.

The outer bark of spruce trees has been flaked off by woodpeckers searching for spruce beetles and larvae

Line Intersect Sampling Method (LIS)

The line intersect procedure is used to estimate the infested bark area per hectare, and the number of spruce beetles per square metre. The product of these estimates times the size of the harvested area gives an estimate of the total beetle population.

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In turn, the estimate of beetle population size is used to estimate the number of trees that could be attacked in the surrounding stands during the beetles' next flight season. Control measures, such as felling trap trees, are required when this number exceeds one tree per hectare. This threshold value is based on the expected number of infested trees and windfalls per hectare in non-outbreak years.

Two distinct procedures are used: one to estimate bark area and numbers of stumps or logs per hectare and one to estimate the spruce beetle population and determine the need for control operations.

LIS Procedures

The optimum time to conduct line intersect sampling is in the late summer or early fall. Five to 20 randomly located points should be located in maps of each harvested area. Each point represents the beginning of a 100-m line transect, randomly oriented by 10° intervals (Figure 1). Line transects can be examined in the field in any sequence to minimize the distance the crew must move from the end of one transect to the beginning of the next.

The survey is best carried out by 2 to 4 people, all equipped and trained to recognize spruce beetles and signs of their presence, and trained to use the necessary tools. One person should be made responsible for recording and tallying. To establish a line transect, the crew proceeds to a point of origin, and two people extend a 50-m tape tightly in the required direction. As they lower the tape to the ground, a third person watches to see which slash pieces and stumps are touched. The line must touch a stump above its midline in order for the stump to be counted. Logs and tops (logs) are counted only if the transect crosses the pith. A log lying with the pith precisely centered along the line likewise does not count. Each piece determined to be "in" should be marked or carefully noted in case the tape is disturbed after it is laid down. The process is repeated for the second half of the transect.

photo: Robert Hodgkinson, BCMOF

Spruce beetle and egg and fan-shaped larval galleries in the phloem of white spruce.

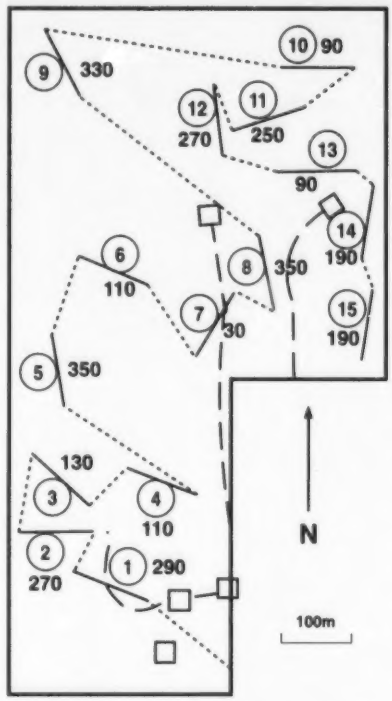


Figure 1. A schematic of randomly selected points within a harvested area and associated transect lines.

Information is recorded separately for each 100-m line transect. All measurements are recorded in metres. The infestation status, height, and mid-diameter of each intersected stump larger than 0.2 m in diameter are recorded. In addition, the infestation status, length, and both end diameters (d1 and d2) of each log with a small-end diameter greater than 0.2 m and longer than 1 m is recorded. The infestation status is determined for each piece by peeling one or more patches of bark (as described below), and looking for live spruce beetles at any stage of development. If they are found, the piece is classified as "infested". If none is found, or if the beetles are dead, the piece is "non-infested" and is not counted in the tally.

Estimating Bark Area and Numbers of Stumps or Logs per Hectare

To estimate the number of stumps per hectare for each slash area:

1. Divide each of the stump mid-diameters (in metres) into 1 (1/mid diam.), and sum the results.
2. Calculate the total length of all of the transects, and divide this figure into 10 000.

3. Multiply the results of Steps 1 and 2 to give number of stumps per hectare.

To estimate the area of bark on stumps in square metres per hectare for each slash area:

1. Sum all of the stump heights.
2. Divide the total length of all of the transects (in metres) into 31 416.
3. Multiply the results of Steps 1 and 2 to give stump bark area per hectare.

To calculate the number of logs per hectare for each slash area:

1. Divide each of the piece lengths (in metres) into 1 (1/length), and sum the results.
2. Divide the total length of all of the transects into 15 708.
3. Multiply the results of Steps 1 and 2 to give the number of logs per hectare.

To estimate the area of bark on logs in square metres per hectare, for each slash area:

1. For each piece, add the diameter measurements (in metres) (d1+d2), and sum the results.
2. Divide the total length of all of the transects into 24 674.
3. Multiply the results of Steps 1 and 2 to give log bark area per hectare.

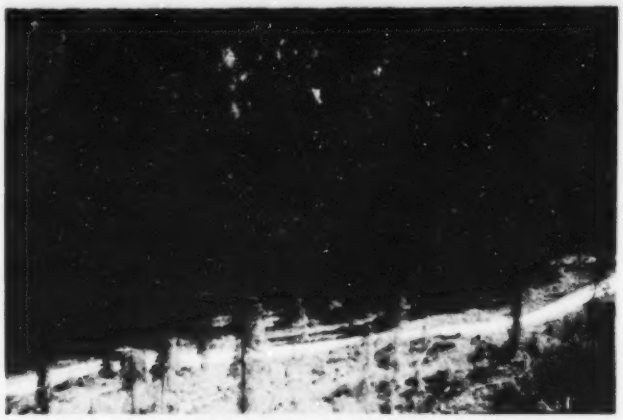
To estimate totals per slash area, multiply any of the per-hectare estimates by the number of hectares.

Procedures for Sampling Broods of Spruce Beetles

Brood sampling is best done using the stumps and logs intersected by the transect lines. This scatters the samples randomly over the entire slash area. Pieces are sampled by removing pairs of bark samples from at least 20 stumps and 20 logs, and counting the numbers of live larvae, pupae, adult beetles, and entrance holes (attacks) found in the inner bark.

Take stump samples from the lower half of the stump. Take log samples from the sides, one from each end at about 1/4 to 1/3 of the total length in from the end.

The samples may be of two types: 15x15-cm squares, or 15-cm diameter circles (discs). Cut the squares with a 5-cm wood chisel and mallet. Cut the discs with a 15-cm-diameter hole saw and a gasoline-powered drill. After each sample is cut, use a knife or narrow chisel to carefully peel it from the stump, taking particular care not to lose any of the beetles that may be underneath. Counting may be done in the field, but it is usually easier to count the beetles indoors; bag and tag the samples in the field for counting later. They can be preserved for a week or more in a refrigerator or cooler (not frozen).



When spruce beetle populations are sufficient and conditions are right, they will kill trees.

Estimating the Number of Spruce Beetles

To estimate the number of spruce beetles per square metre in stumps or logs for each slash area:

1. Find the total from all stump or log samples of larvae and adults (including pupae) separately.
2. Divide the total larvae by 2 (to account for mortality).
3. Sum the totals for adults and larvae/2.
4. Divide the sum from Step 3 by the total number of samples.
5. To determine the number of spruce beetles per square metre for each slash area:

For 15x15-cm square samples: Multiply the answer from Step 4 by 44.44.

For 15-cm round samples: Multiply the answer from Step 4 by 58.14.

6. To estimate the total number of spruce beetles on stumps, multiply the total stump surface area by the total number of spruce beetles per square metre on stumps.
7. To estimate the total number of spruce beetles on logs, multiply the total log surface area by the total number of spruce beetles per square metre on logs.

To estimate the total number of spruce beetles, sum the estimates for each host.

Determining the Need to Control the Spread of Spruce Beetles

To estimate the number of spruce trees potentially subject to attack by spruce beetles:

1. Find the average dbh of spruce in the stand surrounding the slash area.
2. Raise the value of the average dbh (in cm) by a power of 1.6 ($dbh^{1.6}$) and multiply by 2.6 to get the estimated number of beetles required to successfully attack one tree.
3. Divide the total number of beetles per slash area by the estimate from Step 2 to find the number of trees potentially subject to attack in the area surrounding the cutblock.

To determine the number of trap trees needed:

1. Divide the result of Step 3 above by the number of hectares of the clearcut. If this number is less than 1, there is no need for action.

If the result of Step 1 is equal to or greater than 1 then divide the result of Step 3 above by 2 to 4 (depending upon the desired ratio of trap trees to potential standing infested trees) to find the total number of trap trees to be felled.

Management and Planning

Line intersect sampling (LIS) of fresh timber-harvesting debris is a straightforward, efficient, and effective means of estimating the total bark area of debris, and thus the susceptibility of woody debris to infestation by spruce beetles.

Estimating existing brood populations and predicting potential population trends is fundamental in determining pest risks in forest management and planning.

Additional Reading

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